4D flow MRI in renal transplant: preliminary results.

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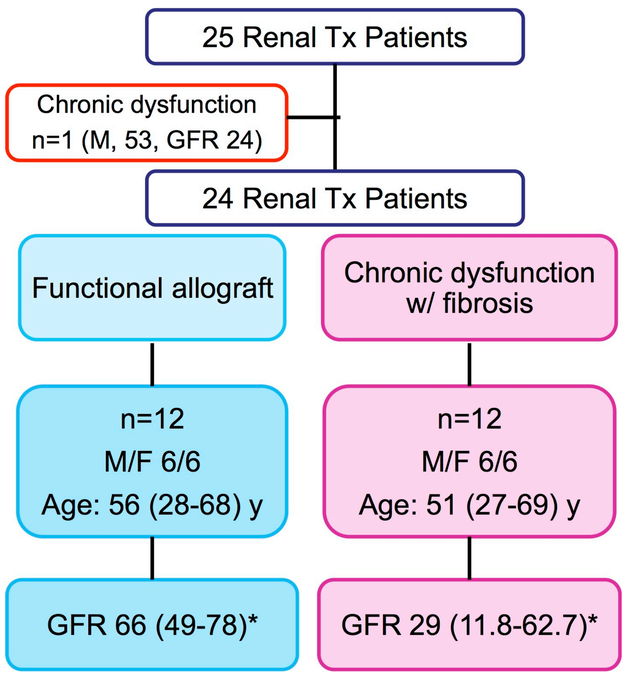
INTRODUCTION

- Significant number of renal transplant patients experience at least one episode of parenchymal allograft dysfunction[1]
- Definitive diagnosis is made by percutaneous biopsy, which is invasive, prone to sampling error and inter-observer variability[2,3]
- Phase-contrast MRI is a promising method for flow quantification of renal transplant vessels, as it does not employ gadolinium-based contrast agents
- Very few studies in renal transplant[4]

Objectives:

1. Report our preliminary experience with 4D flow in renal transplants
2. Determine the test-retest repeatability of flow quantification in renal allograft vessels
3. Correlate flow parameters with serum eGFR and DCE-MRI.

METHODS



- Prospective IRB-approved single center study
- 4D flow acquired as part of mpMRI protocol
- 4D flow acquisition: coronal-oblique abdominal 60 mm slab (TR/TE/FA 62.4/2.9/9º, FOV 400x400 mm, acquired matrix size 160 x 160 x12, acquired voxel size 2.5 x 2.5 x 5 mm^3, interpolated voxel size 1.3 x 1.3 x 2.5 mm^3, temporal resolution 66-71 ms), covering the renal allograft in the pelvis. 4D flow was acquired for 3 minutes during free breathing, with velocity encoding parameters (V_{ENC}) of 120 and 45 cm/sec.
- Images analyzed using prototype software (Siemens Healthcare) by 2 observers in consensus.
- Main stems of the renal artery (RA) and renal vein (RV), as well as ipsilateral illiac artery (ILA) were identified and segmented **(Fig.1.)**
- Test-retest repeatability for flow metrics assessed by coefficients of variation (CV) in 3 patients (average delay of 24 days between MRIs).

RESULTS

- Excellent agreement between test-retest sessions in segmenting the vessels (Cohen's kappa=1, p=0.046).
- Significantly decreased RA flow (p=0.039) in patients with allograft dysfunction (**Fig. 2**)
- Significantly decreased RV flow (p=0.019) in patients with allograft dysfunction (**Fig. 3**)
- RA flow had a moderate negative correlation with the Banff fibrosis score ci (**Fig. 4**; r=-0.6, p=0.03 in 10 patients)
- RA flow (Spearman's r=0.50, p=0.016), RV flow (r=0.56, p=0.007) and velocity (r=0.46, p=0.034) were moderately correlated with serum eGFR.
- RA flow was negatively correlated with mean transit time from DCE-MRI in the allograft (r=-0.76, p=0.016) and loop of Henle (r=-0.77, p=0.014) obtained from a three-compartment model[6].

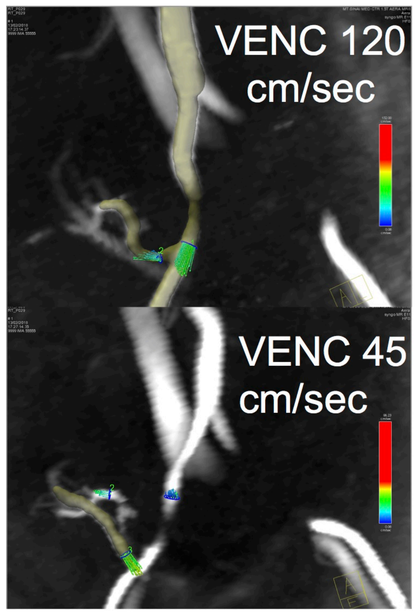


Figure 1. 4D flow processing in a patient (male, 42 years) with right sided renal allograft with severe fibrosis (iIFTA 3, ci 3, ct 2). Vessel ROIs with flow vectors in the RA, ILA (measured with VENC=120 cm/s) and RV (measured at 45 cm/s).

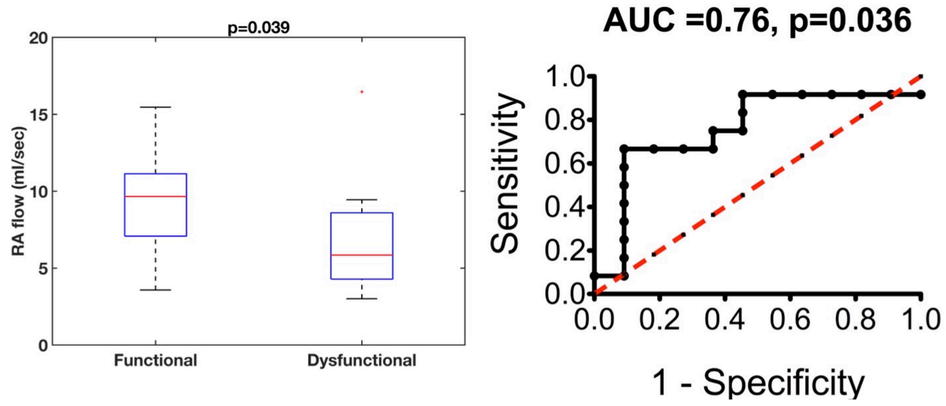


Figure 2. RA flow distinguishes dysfunctional from functional allografts with sensitivity 0.67, specificity 0.9 at a threshold of 6.5 ml/sec.

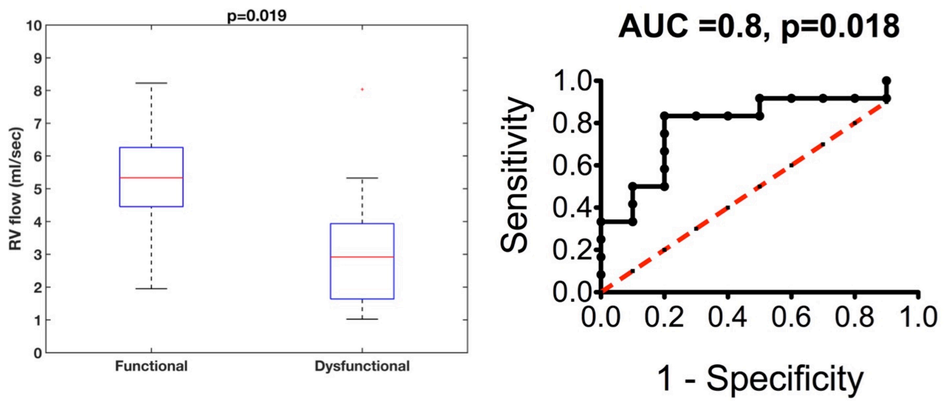


Figure 3. RV flow distinguishes dysfunctional from functional allografts with sensitivity 0.83, specificity 0.8 at a threshold of 4.3 ml/sec.

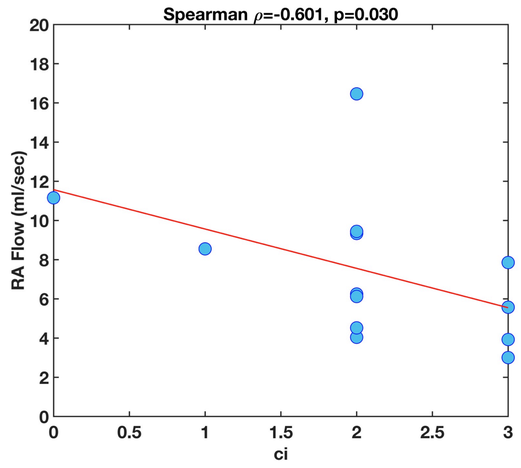


Figure 4. RA flow showed a moderate negative association to fibrosis Banff score ci, in 10 patients with no history of allograft RAS.

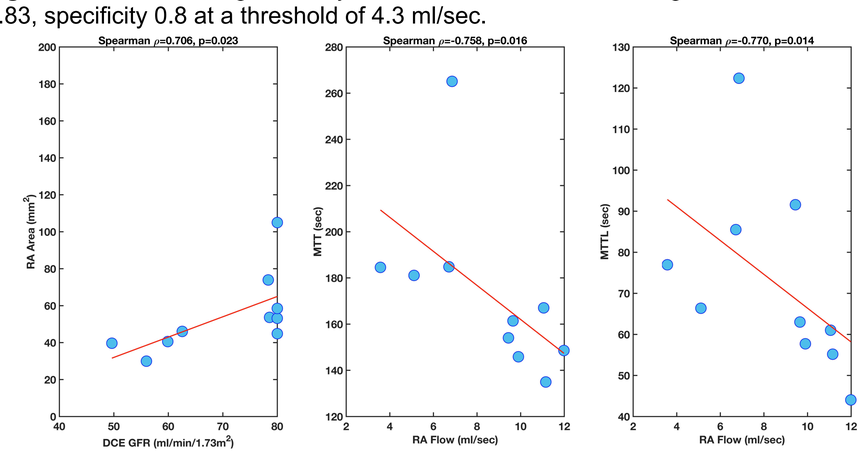


Figure 5. RA area and flow shows strong correlations to allograft DCE-MRI parameters obtained in functional allografts from a three-compartment model[6].

CONCLUSION

- Factors that restrict RA flow, such as renal artery stenosis (RAS), may affect renal function and blood pressure regulation after transplantation.
- The development of fibrosis with decreased RA flow has been shown in animal models of RAS[5]
- No patients in our cohort had a history of RAS, so the association of RA flow and fibrosis will be confirmed in a longitudinal study.
- Our study shows that 4D flow can potentially be used as a non-contrast method to diagnose renal dysfunction.

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